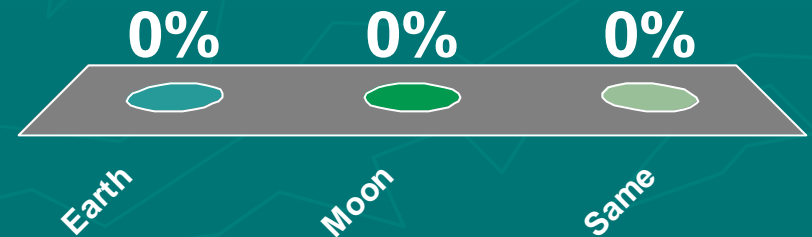


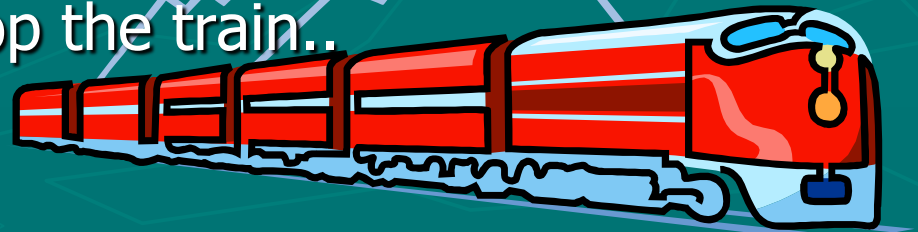
What has more mass, a 50N block on the moon, or a 50N block on the Earth?

1. Earth
2. Moon
3. Same



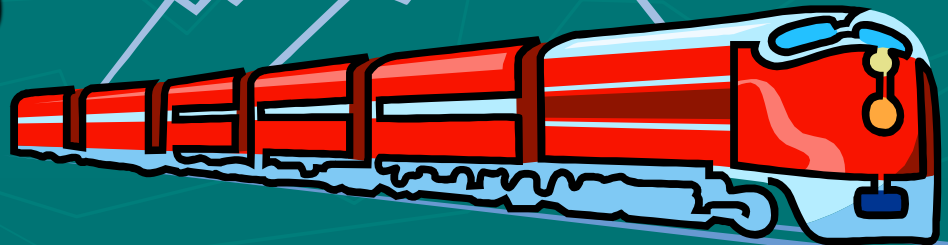
Sidekick Saves Hero

- Because of your physics background, you have been able to get a job with a company devising stunts for an upcoming adventure movie being shot in Minnesota. In the script, the hero has been fighting the villain on the top of the locomotive of a train going down a straight horizontal track at 20 mph. He has just snuck on the train as it passed over a lake so he is wearing his rubber wet suit. During the fight, the hero slips and hangs by his fingers on the top edge of the front of the locomotive. The locomotive has a smooth steel vertical front face. Now the villain stomps on the hero's fingers so he will be forced to let go and slip down the front of the locomotive and be crushed under its wheels. Meanwhile, the hero's partner is at the controls of the locomotive trying to stop the train..



Sidekick Saves Hero

- To add to the suspense, the brakes have been locked by the villain. It will take her 10 seconds to open the lock. To her horror, she sees the hero's fingers give way before she can get the lock off. Since she is the brains of the outfit, she immediately opens the throttle causing the train to accelerate forward. This causes the hero to stay on the front face of the locomotive without slipping down giving her time to save the hero's life. The movie company wants to know what minimum acceleration is necessary to perform this stunt. The hero weighs 180 lbs in his wet suit. The locomotive weighs 100 tons. You look in a book giving the properties of materials and find that the coefficient of kinetic friction for rubber on steel is 0.50 and its coefficient of static friction is 0.60



Factors that affect Friction

- ▶ The magnitude of the friction force acting on an object depends on two things.
- ▶ Contact Material: The type of material the object is made of and the type of material it is sliding on makes a difference.
- ▶ Example #1: A waxed snowboard will experience little friction against powdery snow.
- ▶ Example #2: A waxed snowboard will experience quite some friction against a paved asphalt road.

Factors that affect Friction

- ▶ Normal force: How hard the surface is pushing on the object will affect how much friction acts on the object.
- ▶ Example #1: A heavy crate sliding will experience more friction than a light crate sliding across the same surface.
- ▶ Example #2: A crate sliding down a 10° incline will experience more friction than the same crate sliding down a 30° incline.

Lesson #36

Topic: Coefficient of Friction

Objectives: (After this class I will be able to)

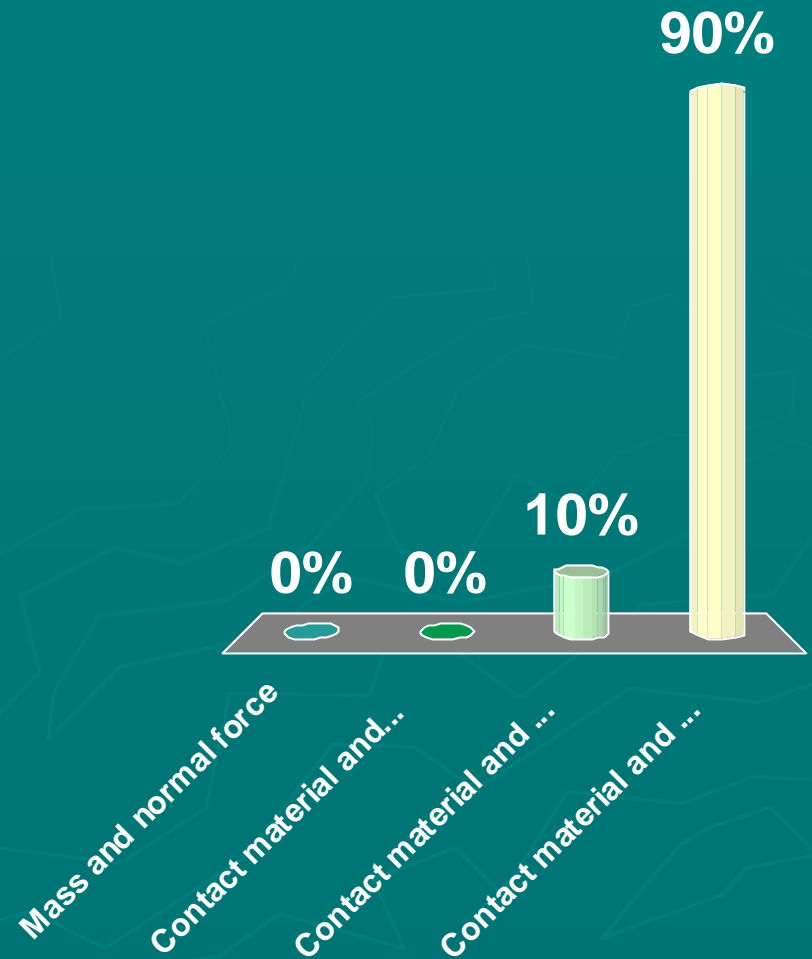
1. State the variables that affect the force of friction.
2. Define coefficient of friction.
3. Solve problems involving coefficient of friction.

Project: From yesterday's lab, discuss what factors affected the force of friction.

Assignment: "Coefficient of friction practice" due Monday

Friction force depends on...

1. Mass and normal force
2. Contact material and mass
3. Contact material and weight
4. Contact material and normal force



Coefficient of Friction

- ▶ For every combination of two contact materials there is a specific ratio between friction force and normal force.
- ▶ This ratio is called coefficient of friction.
- ▶ Examples:

Surface	Coefficient
Wood on wood	$\mu = 0.4$
Ice on ice	$\mu = .01$
Steel on steel	$\mu = .07$
Rubber on concrete	$\mu = 1.0$

Coefficient of Friction

- This ratio between forces can be expressed by:

$$\mu = \frac{F_f}{F_n}$$

or

$$F_f = \mu F_n$$

- The first step to these problems is to solve for F_n first.

Example: What is the coefficient of friction between Fred and the table if I push him along at constant speed with a force of 10N? Fred has a mass of 5kg.



Coefficient of Friction

1. I push downward with a force of 100N and to the right with a force of 50N onto a 1kg book at rest on a table. The book moves at constant speed. Find the coefficient of friction between the book and the table.



Coefficient of Friction

2. I lift upward with a force of 5N onto a 1kg book at rest on a table. With what additional force do I need to press onto the side of the book to make the book move at constant speed? $\mu = 0.2$



Coefficient of Friction

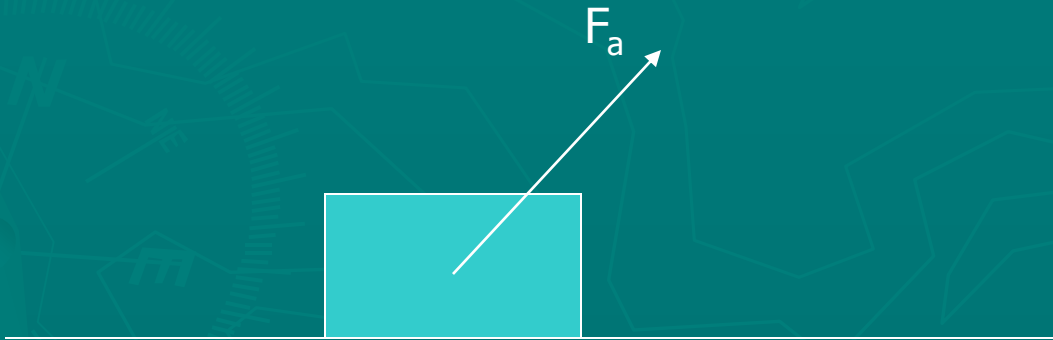
3. If I push on a 1kg book with a force of 100N, I can hold it at rest against the wall.

Find the coefficient of friction between the book and the wall.



Coefficient of Friction (3pt Bonus)

- ▶ As I take Fred (5kg) for his morning walk I pull on his leash with a force of 20N at an angle of 50° to the horizontal. Find the acceleration of Fred if the coefficient of friction between Fred and the floor is 0.2.



Lesson #37

Topic: Coefficient of Kinetic vs. Static Friction

Objectives: (After this class I will be able to)

1. Explain the difference between static and kinetic friction.

Warm Up: If you were sliding a crate of bricks across the floor, is it harder to get the crate to start to slide or to keep sliding?

Assignment: "Static and Kinetic friction" due Tomorrow

Kinetic vs. Static

- ▶ Kinetic: Means motion, so force of Kinetic Friction would be the friction force acting on an object in motion.
- ▶ Static: Means at rest, so the force of Static Friction would be the friction force acting on an object at rest.
- ▶ The force of friction acting on an object decreases when an object begins to move.

Static Friction

- ▶ Static friction can range from 0N to some maximum amount.
- ▶ Example: The amount of force needed to get Fred to move is 10N. What is the friction force acting on Fred when...
 - a. There is no force acting on Fred?
 - b. I push on him with 1N of force?
 - c. I push on him with 8N of force?
 - d. I push on him with 10N of force?

Kinetic Friction

- ▶ After I reach 10N of force, Fred will accelerate, and the force of friction acting on him will decrease.
- ▶ The force of friction acting on Fred while he is in motion is a constant, fixed number that is less than the maximum force of static friction.
- ▶ Example: Fred moves at a constant speed when I push on him with 9N of force. What is the force of friction acting on him when...
 - a. I push with 9N of force?
 - b. I push with 10N of force?
 - c. I push with 100N of force?

Coefficients of Kinetic and Static Friction

- ▶ Since the force of friction is different for Kinetic and Static, then the coefficients of friction are different as well.
- ▶ If a problem refers to a moving object, then you use or solve for μ_k .
- ▶ If a problem refers to an object at rest, then you use or solve for μ_s .
- ▶ $\mu_s > \mu_k$

Example

- ▶ Fred begins to move when I push on him with 10N of force, and moves at a constant speed when I push on him with 9N of force. Fred has a mass of 5kg.
- ▶ What are the coefficients of static and kinetic friction between Fred and the table?

Project

- ▶ Solve for the coefficient of static friction and the coefficient of kinetic friction found between a wood block and an aluminum track.
- ▶ Do the same for a felt block.
- ▶ Assignment: p133 #33-37 due tomorrow.
- ▶ Bonus: p132 Challenge Problem
- ▶ Complete "Sidekick Saves Hero"

Construction Site

- You are passing a construction site on the way to physics class, and stop to watch for awhile. The construction workers appear to be going on coffee break, and have left a large concrete block resting at the top of a wooden ramp. As soon as their backs are turned, the block begins to slide down the ramp. You quickly clock the time for the block to reach the bottom of the ramp at 10 seconds. You wonder how long the ramp is. You estimate that the ramp is at an angle of about 20° to the horizontal. In your physics book you find that the coefficient of kinetic friction between concrete and wood is 0.35.



Lesson #38

Topic: Coefficient of Friction and Inclines

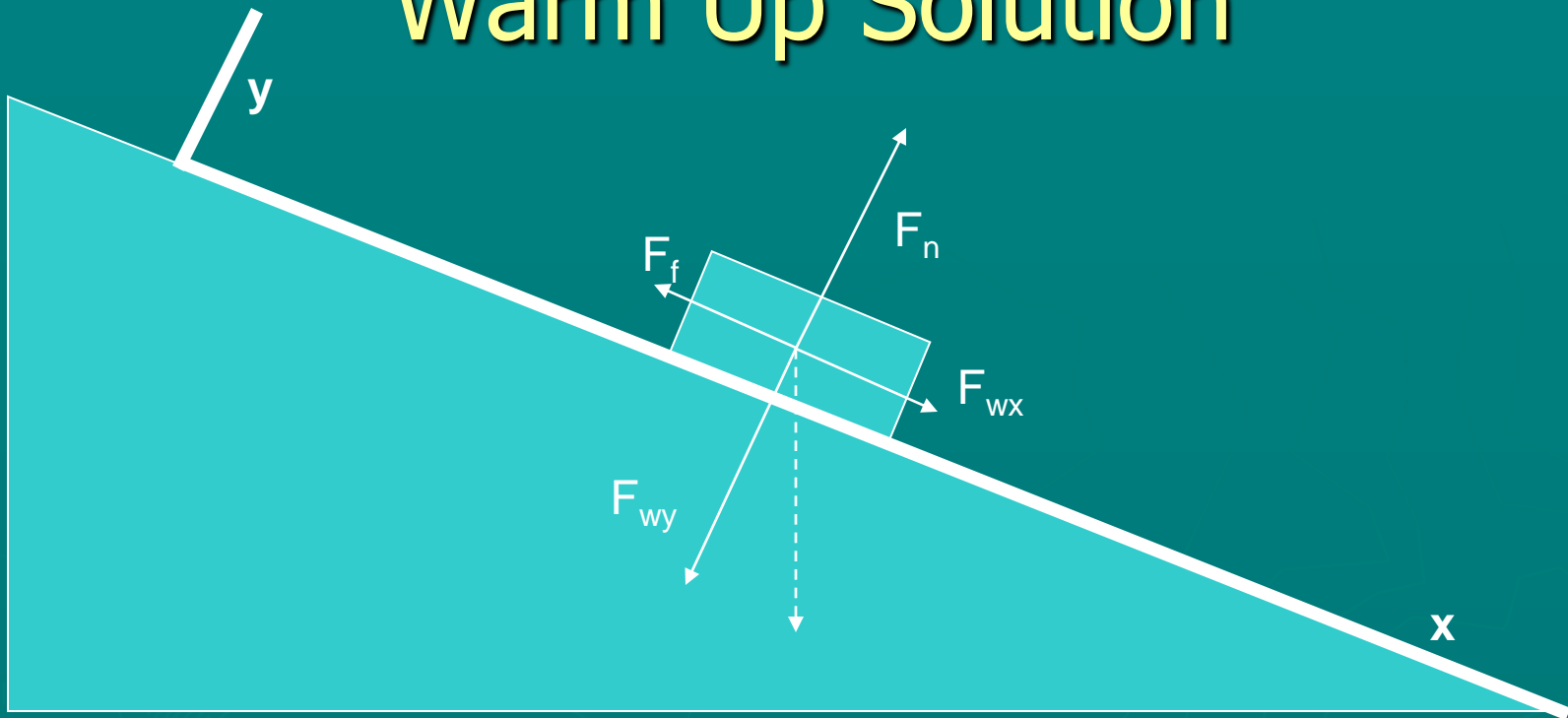
Objectives: (After this class I will be able to)

1. Solve for the correct coefficient of friction depending on the motion or non-motion of an object on an inclined plane.

Warm Up: A wood block on an inclined plane will just start to slide when the plane is raised to make an angle of 30° to the horizontal. What is the coefficient of static friction between the block and the plane?

Assignment: p135 #38 - 41, 44 due tomorrow

Warm Up Solution

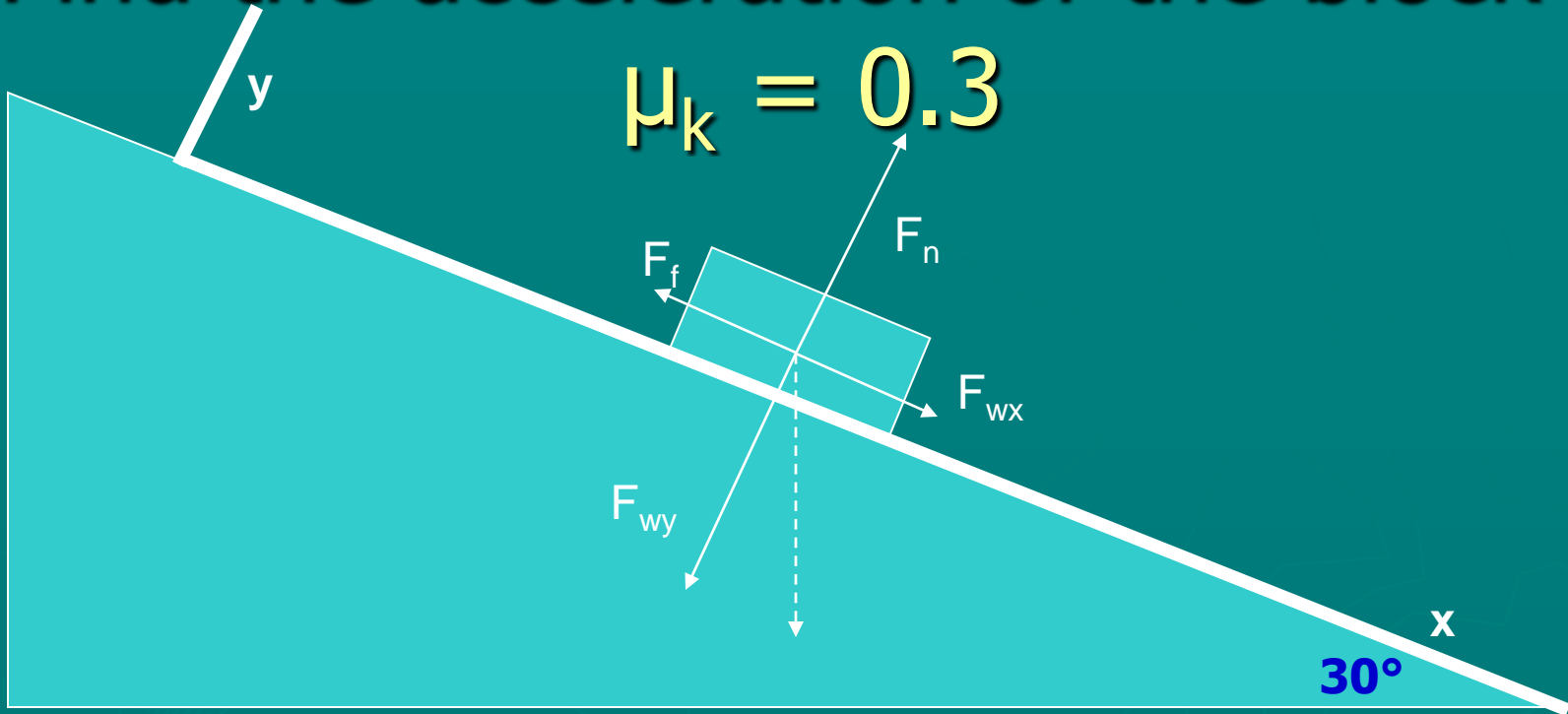


The coefficient of static friction is
 than kinetic friction.

1. Always bigger
2. Always smaller
3. The same
4. Sometimes bigger

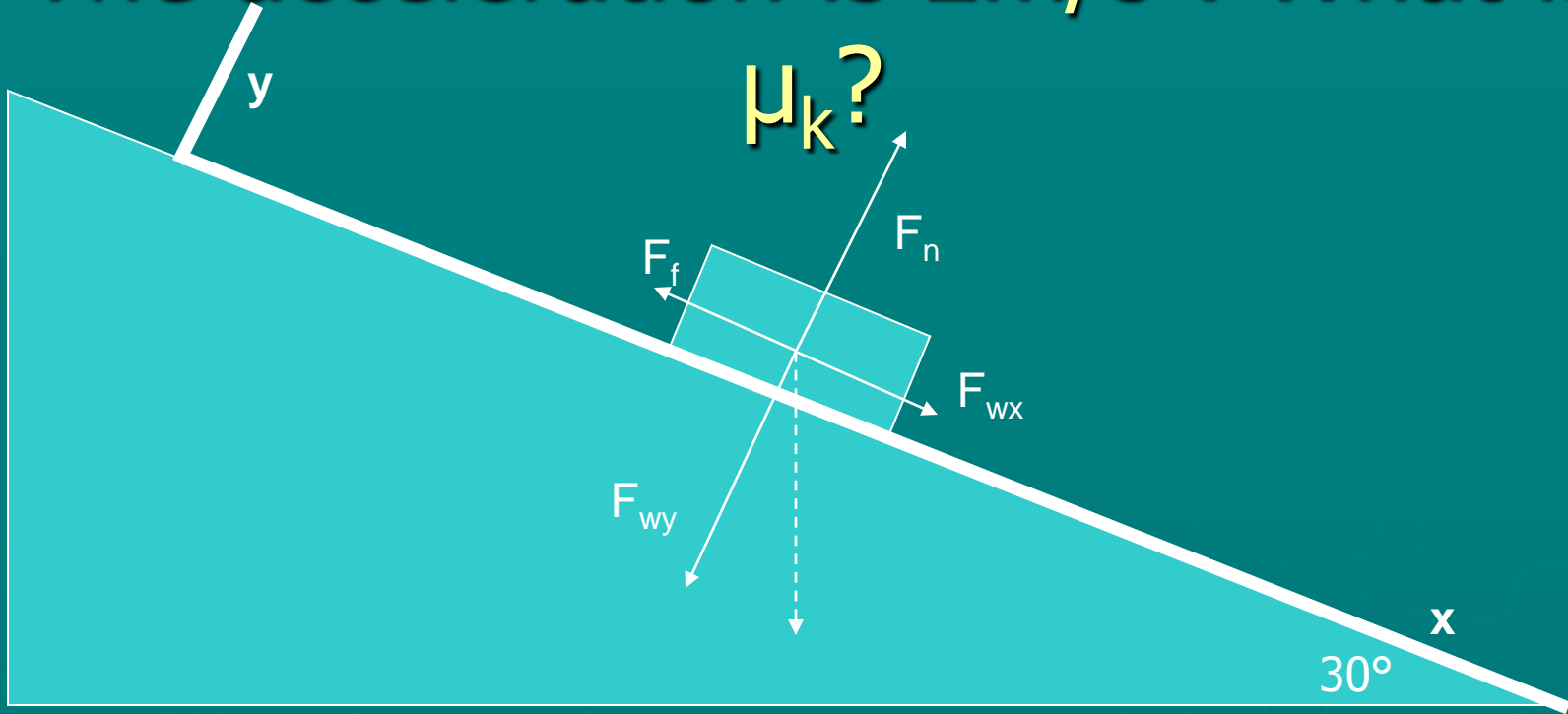
Find the acceleration of the block if

$$\mu_k = 0.3$$

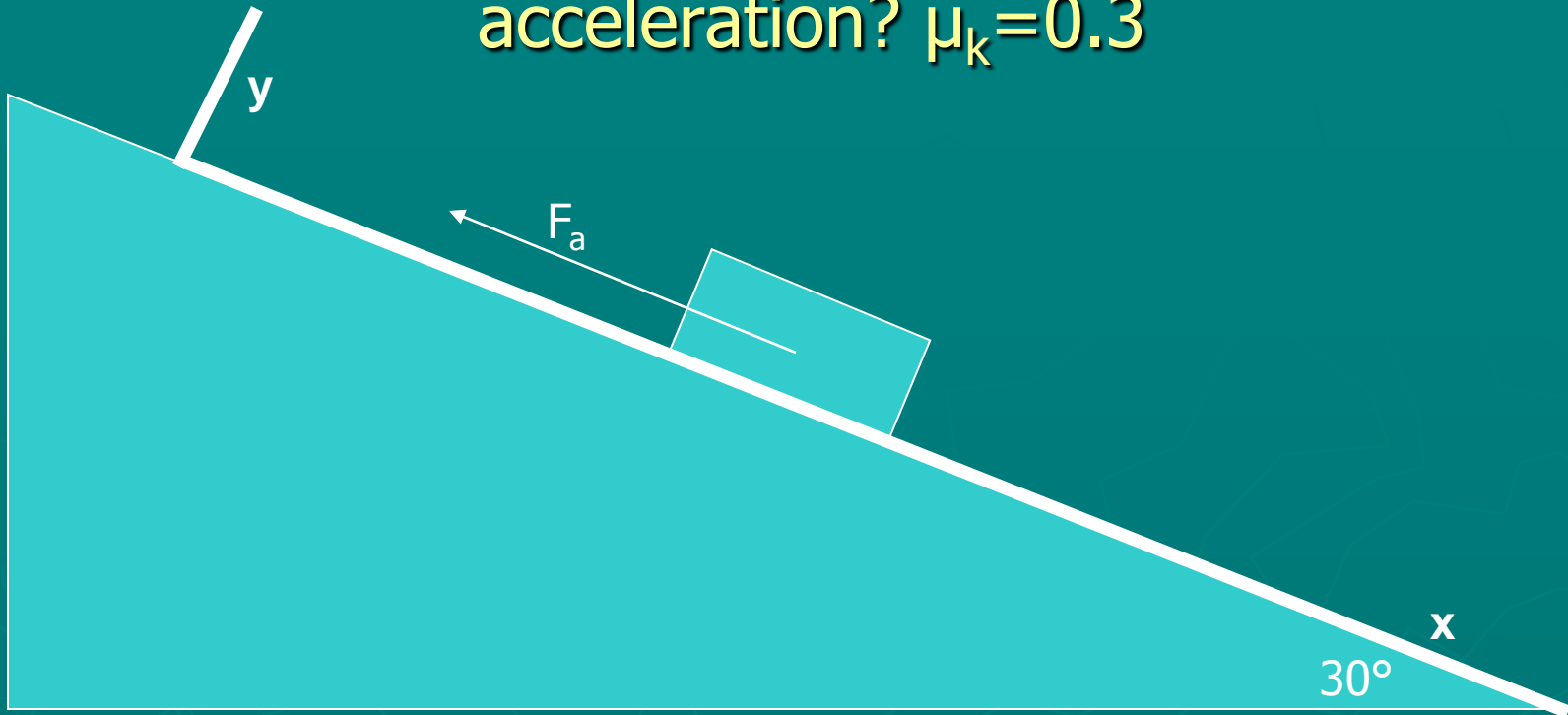


The acceleration is 2m/s^2 . What is

μ_k ?



There is a 30N applied force up the ramp. Which way does the 3kg block move? With what acceleration? $\mu_k=0.3$



Construction Site

- ▶ Find out how long the ramp is at the construction site.
- ▶ Show all work.
- ▶ Stuffed Poodle quiz

Lesson #39

Topic: Exam 5 Review

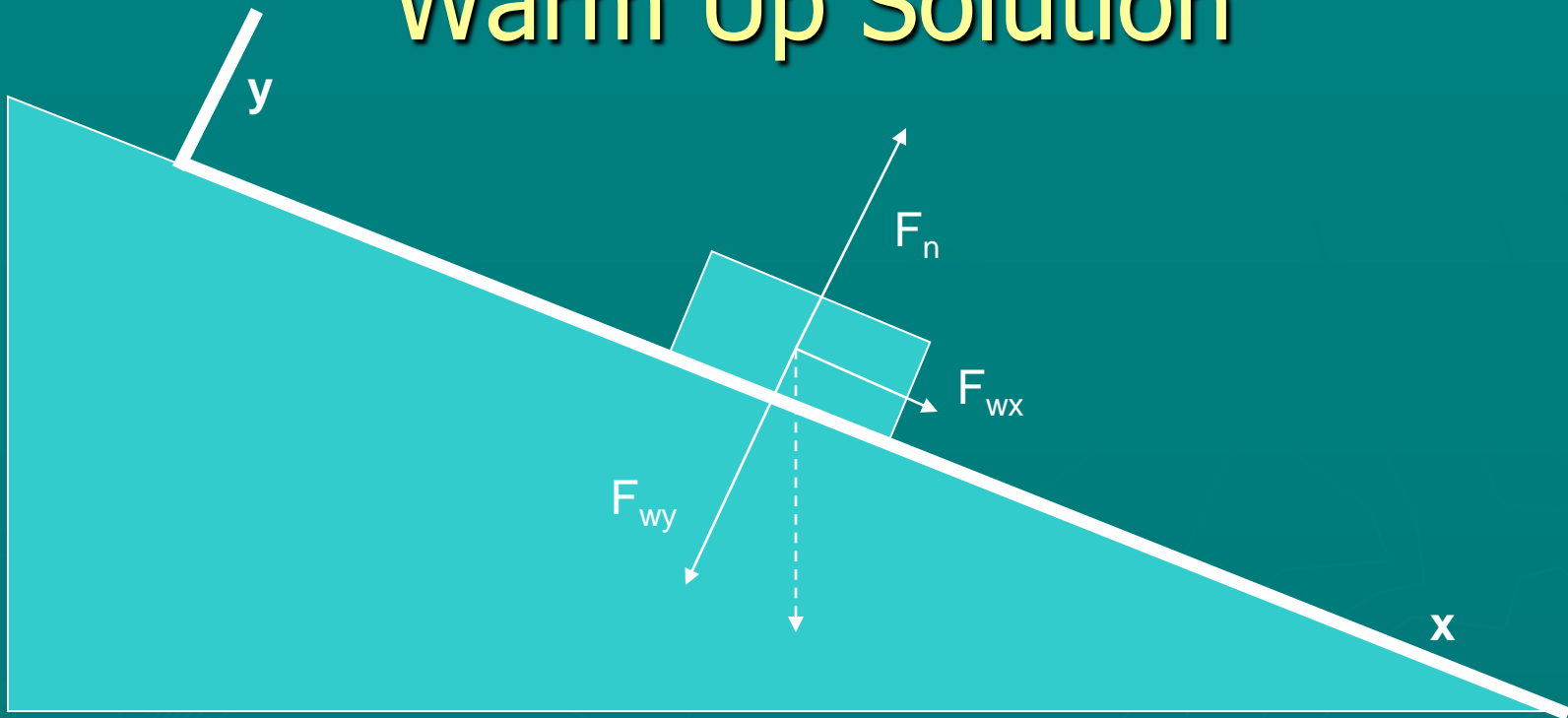
Objectives: (After this class I will be able to)

1. Practice solving physics problems
2. Complete and check Exam 5 Review
3. Plan a tutoring time (if needed)
4. Complete a bonus problem opportunity

Warm Up: A cart is set at the top of an incline and released from rest. Its final velocity as it reaches the bottom of the incline is 6m/s and it takes 2 seconds to reach the bottom of the incline. What is the angle of the incline? (assume there is no friction)

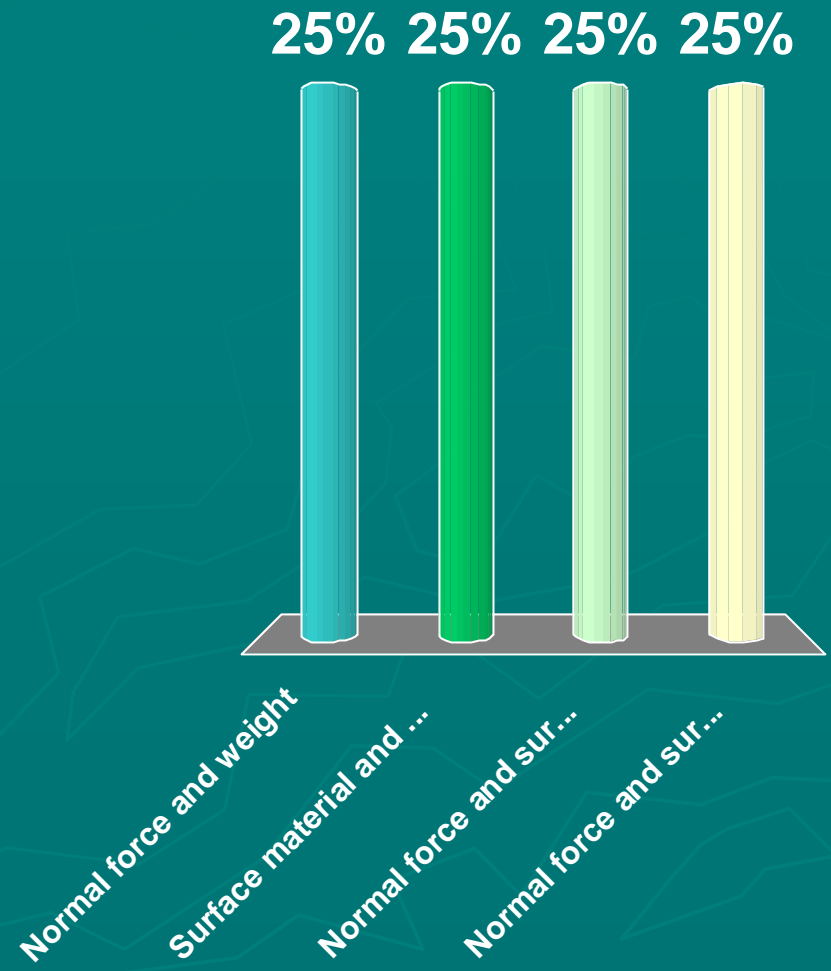
Assignment: Exam 5 Review due ! Study for Exam 5.

Warm Up Solution



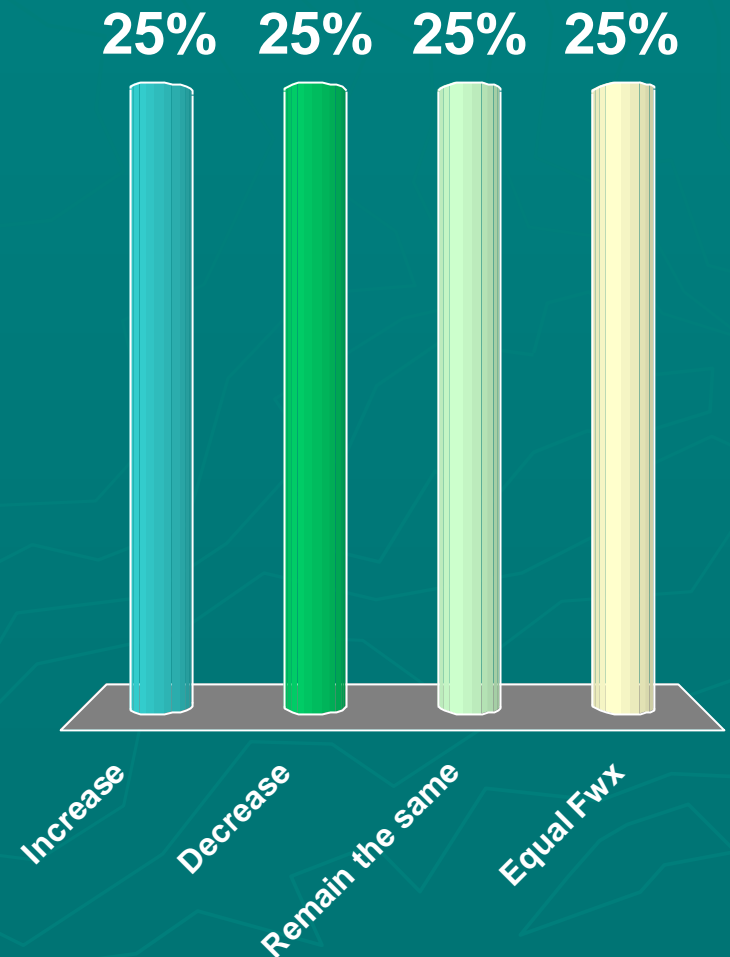
What affects friction?

1. Normal force and weight
2. Surface material and surface area
3. Normal force and surface material
4. Normal force and surface area



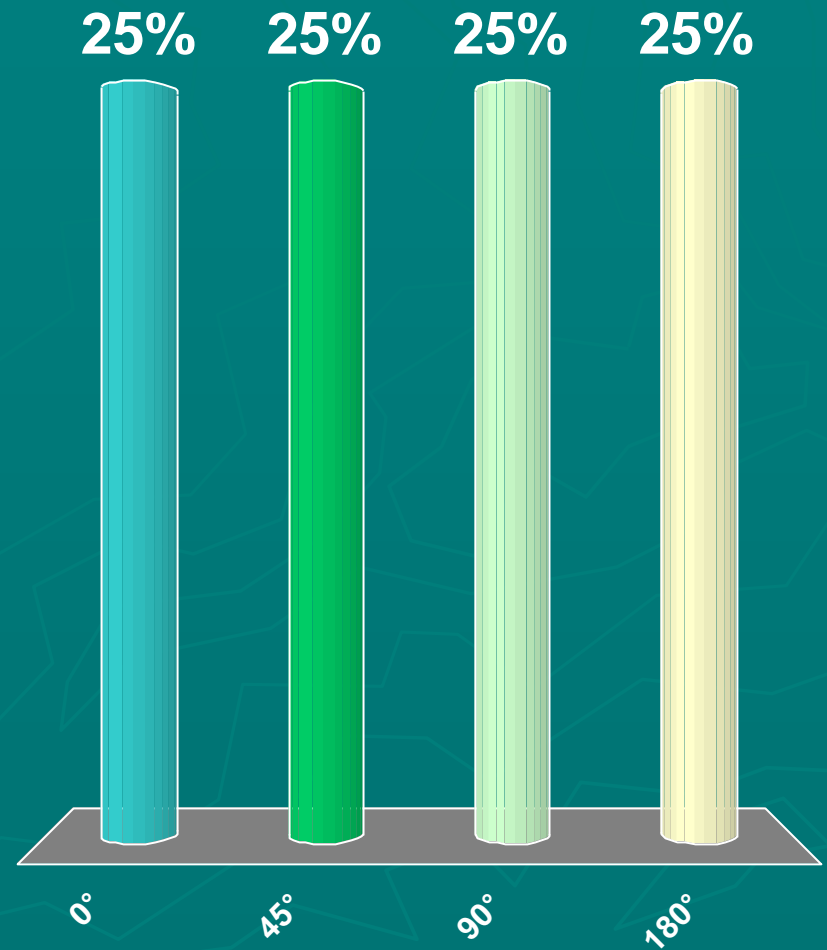
As the angle of an incline increases, normal force will...

1. Increase
2. Decrease
3. Remain the same
4. Equal F_{wx}



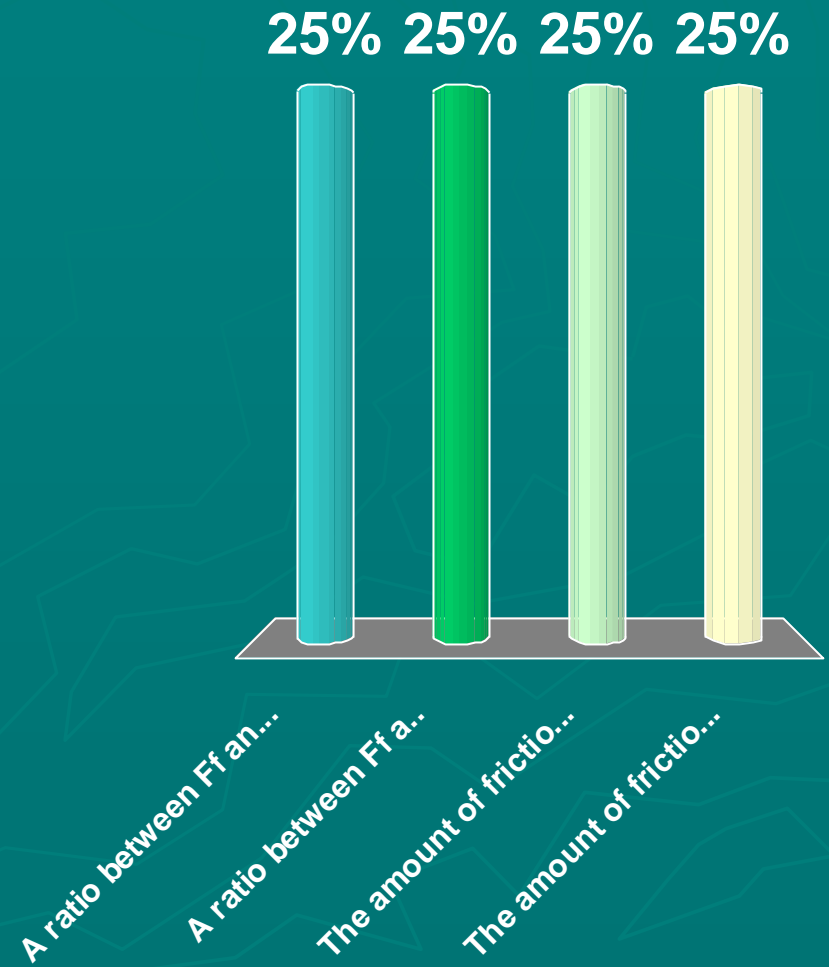
F_{wx} is at a maximum when the angle of the incline is ...

1. 0°
2. 45°
3. 90°
4. 180°



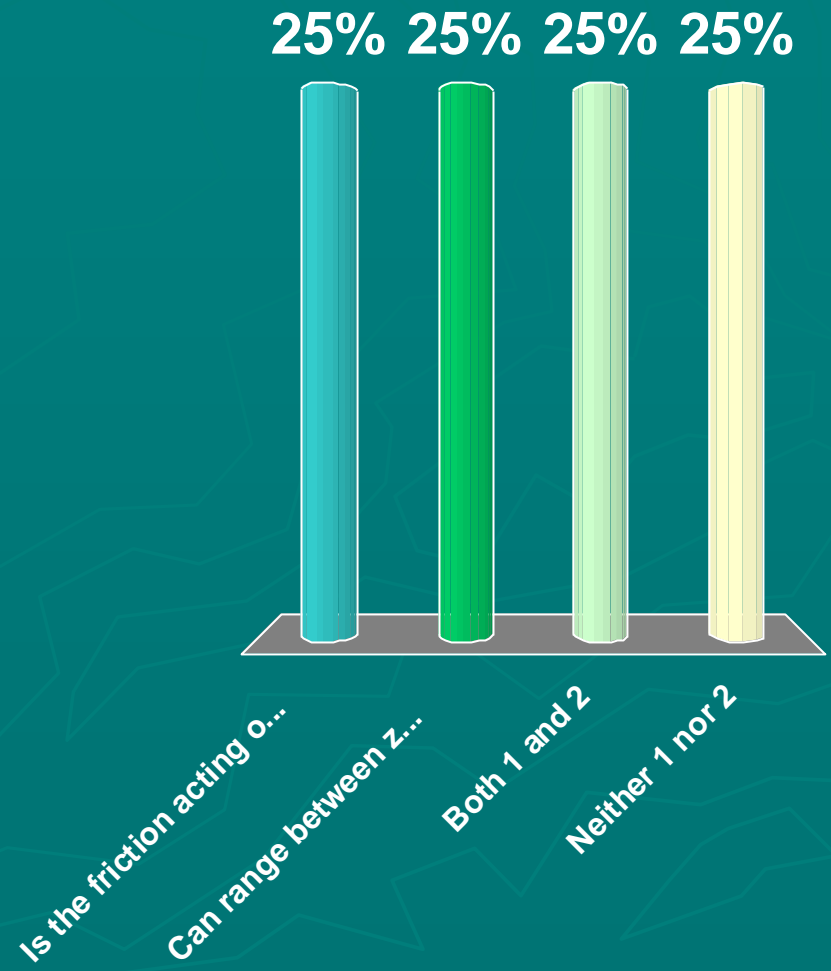
Coefficient of friction is

1. A ratio between F_f and F_n that is the same for all objects
2. A ratio between F_f and F_n that is specific to that material
3. The amount of friction any object will encounter
4. The amount of friction a specific material will encounter



Static friction ...

1. Is the friction acting on an object at rest.
2. Can range between zero and the maximum friction force
3. Both 1 and 2
4. Neither 1 nor 2



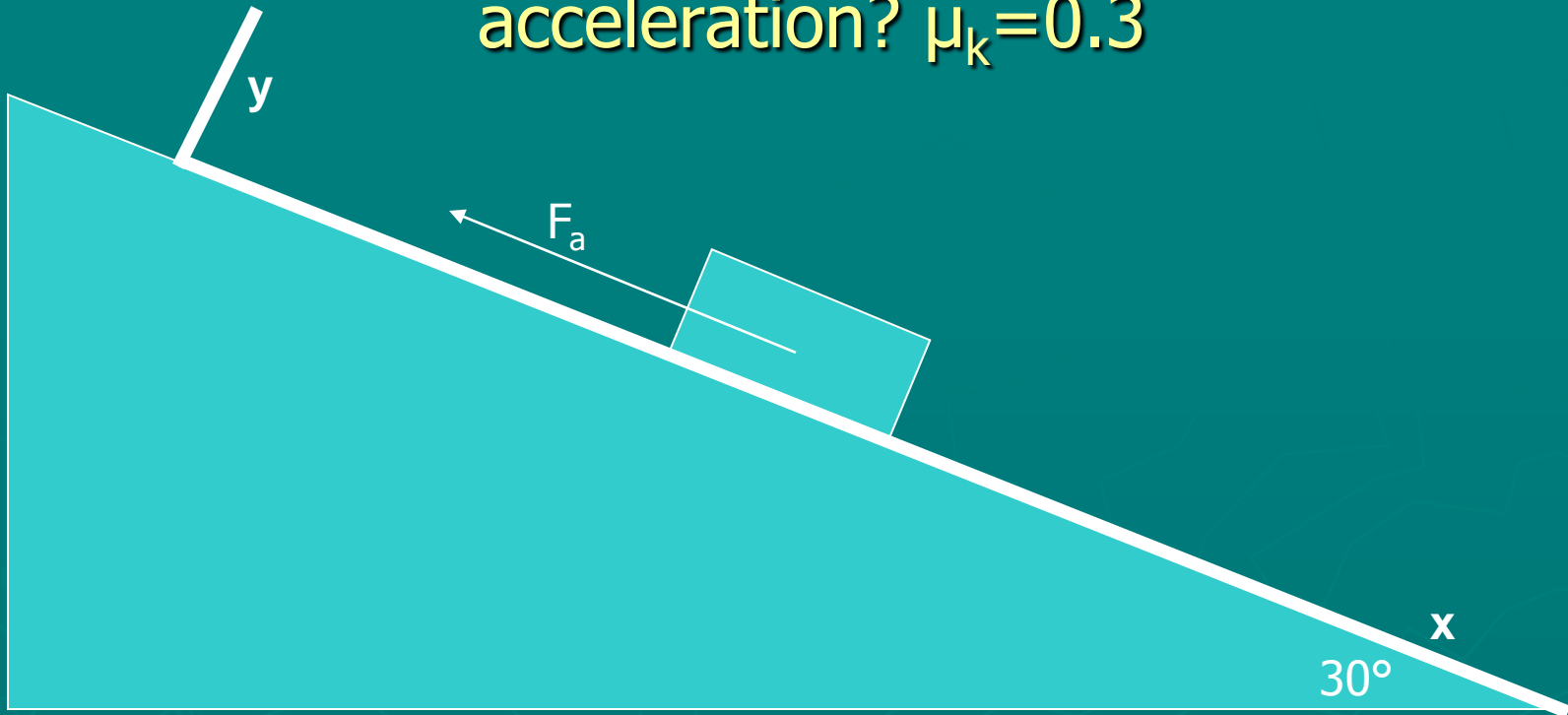
Practice

1. A flatbed truck is carrying a heavy crate. The coefficient of static friction between the crate and the bed of the truck is 0.65. What is the maximum rate at which the driver can decelerate and still avoid having the crate slide against the cab?

Practice

1. A 20 kg box slides down a ramp with constant speed. The force of kinetic friction between the box and the ramp is 60N. What is the angle of the incline?

There is a 30N applied force up the ramp. Which way does the 3kg block move? With what acceleration? $\mu_k=0.3$



Bonus

- ▶ A roller coaster reaches the top of the steepest hill with a speed of 6 km/h. It then descends the hill at a 45° angle. The hill is 45 m long. What is the speed of the coaster at the bottom of the hill? Assume $\mu_k = .12$.